LUMINAIRES

The following data is intended to be a helpful guide when selecting or specifying a lighting system.

Lighting Terminology

Luminous Intensity (I) : Expressed in candelas (cd), it is the quotient of the luminous flux leaving the source propagated in an element of solid angle in a specific direction and the element of solid angle.

Luminous Flux (F) : Expressed in Lumens (lm), it is quantity of radiant flux capable of producing visual sensation irrespective of direction. A lumen is the light flux falling on a Surface of one square foot in area, every part of which is one foot from a point source having a luminous intensity of one candela in all directions.

Illuminance (E) : Expressed in Lux (lx), it is density of luminous flux on a surface and is measured by the quantity of lumens falling on an unit area. One Lux is equal to one Lumen per square metre.

Luminous Efficacy : Expressed as Lumens per watt is the quotient of the luminous flux emitted by a light source and the total power consumed.

Cosine Law : This law states that the illuminance at a point on a plane is proportional to the cosine of the angle of light incident E = 1 x Cos x/d2.

Direct Flux : Is the luminous flux reaching the reference plane directly from all the luminaries in any installation.

Indirect Flux : Is the luminous flux reaching the reference plane after reflection against other surfaces

Inverse Square Law : States that the illuminance at a point on a plane perpendicular to the line joining the point and a source is inversely proportional to the square of the distance between the source and the plane. E = I/d2

Isocandela Diagram : Is the curve traced on an imaginary sphere with the source at its center and joining all adjacent points corresponding to those directions in which the luminous intensity is the same.

Isolux Diagram : Is the locus of points on a surface where the illuminance has the same value.

Luminous Intensity Diagram : Is the luminous intensity shown in the form of a polar diagram in terms of candela per 1000 lumens of lamp flux. The luminous intensity diagram can be used.

a. To provide a rough idea of the light distribution of the luminaire.

b. For the calculation of illuminance values at a point.

c. For the calculation of the luminance distribution of the luminaire.

Utilisation Factor : Is the ratio of the utilized flux on the working plane to the luminous flux emitted by the lamp.

Maintenance Factor : Is the ratio of the average illuminance on the working plane after a certain period of use to the average illuminance obtained under the same conditions for a new installation.

Light Sources :

Lamp manufacturers are continually developing new lamps and improving existing ones. It is therefore essential to understand the various characteristics of the different lamps so that a proper light source can be selected for a given application. The principal, characteristics of the various lamps are indicated below :

Principal characteristics of lamps employed for general lighting purposes.

Characteristics	GLS	Halogen	SL*	PL*	'TL'	ML	HPL	HPI	SOX	SON
Luminous flux lm	250 to 40000	10000 to 45000	450 to 1200	400 to 900	150 to 5300	3100 to 14000	2000 to 12500	19000 to 18700	1800 to 33000	3300 to 130000
Efficacy lm/W (without ballast)	10 to 20	22	41 to 50*	59 to 78	38 to 91	19 to 28	40 to 63	75 to 95	100 to 183	70 to 130
Rating W	25 to 2000	500 to 2000	9 to 25	7 to 11	4 to 65	160 to 500	50 to 2000	250 to 2000	18 to 180	50 to 1000
Light colour	warm-white	warm-white	warm-white	warm-white	Warm-white intermediate cool	intermediate	intermediate	cool	warm-white	warm-white
Colour rendering	excellent	excellent	good	good	excellent to moderate	moderate	moderate	excellent to good	non-existent	poor
Ballast	none	none	built-in	choke	choke	none	ckoke	choke	hybrid	choke
Starter / Ignitor	none	none	built-in	built-in	starter or starterless	none	none	ignitor	seperate or built-into ballast	ignitor separate or built-into lamp
Run-up time min	zero	zero	zero	zero	zero	zero to 2	3	3	10	5
Restrike time min	zero	zero	zero	zero	zero	5	5	10	2	< 1

LUMINAIRES

Lamp Efficiency :

The efficacy of any lamp is the average lumen output of the lamp divided by the total power of the lamp in waits. This is an indication therefore of the efficiency with which the lamp converts 1 watt of electrical energy into luminous energy. The efficacy depends not only on the wattage of the lamp but also upon the type of construction of the lamp. For example a 40W GLS lamp has an efficacy of 10.6 lumen/watt whereas 40W fluorescent lamps have an efficacy of 69.2 lumen/watt.

Wattage	Type	Luminous Flux	Lumen / Watt
25 W	GLS	220	8.8
40 W	GLS	425	10.6
40 W	GLS	720	12.0
100 W	GLS	1380	13.8
150 W	GLS	2080	13.9
200 W	GLS	2920	14.6
300 W	GLS	4700	15.7
500 W	GLS	8300	16.6
1000 W	GLS	18600	18.6
1500 W	GLS	29500	19.7

Wattage	Type	Luminous Flux	Lumen / Watt
20 W	FTL	1160	58.0
40 W	FTL	2770	69.2
65 W	FTL	4000	61.5
80 W	HPMV	3400	42.5
125 W	HPMV	5800	46.4
250 W	HPMV	12500	50.0
400 W	HPMV	2250	56.2
1000 W	MPMV	55000	55.0
160 W	MLL	2900	18.1
250 W	MLL	5200	20.8
250 W	SON	25000	100.0

Horizontal illumination

α	Eh	lux
O	$\frac{156 \times 6.4}{4^2}$	= 62.4
30	$\frac{156 \times 6.4 \times 0.65}{4^2}$	= 39.0
45	$\frac{140 \times 6.4 \times 0.35}{4^2}$	= 19.6
60	$\frac{120 \times 6.4 \times 0.125}{4^2}$	= 6.0

Where h = 4
I = To be read from polar diagram

LUMINAIRES

Lighting Design :

The design of lighting for a given area involves a clear understanding of not only the various types of luminaries available but also the different factors that affect the distribution of light from these luminaries. Some of the factors that affect the light output of a luminaire are

1. Luminaire design
2. Light source
3. Reflector, design and material
4. Position of lamp source within luminaire
5. Refractor design and material
6. Diffuser design and material
7. Quality and thickness of glass
8. Presence of any wireguards
9. Environmental conditions and
10. Frequency and quality of maintenance

An understanding of the above helps in working out the efficiency of the luminaire or the light loss factor which is vital for correct lighting design. While factors 1 to 8 depend upon the luminaire manufacturer factors 9 & 10 are dependent upon the user. The quality of maintenance and the amount of dust accumulated on a luminaire can drastically affect the light output.

The factors to be taken into account for lighting design are.

1. Luminaire Light distribution data.
2. Luminaire description
3. Shielding angle of reflectors
4. Coefft, of utilization
5. Reflectance of walls, ceiling, floor
6. Luminaire spacing
7. Luminaire mounting height
8. Beam spread
9. Ambient environment
10. Maintenance factors.

Lighting Calculations :

Once tentative lamp and luminaire choices have been made, the designer can proceed with the lighting calculations. There are 2 methods commonly used to calculate illumination in indoor and outdoor spaces.

These are :

a. Point by point method using the inverse square and cosine laws with data from the polar curves.

b. Lumen method involving the zonal cavity method of obtaining the coefficient of utilization.

Lumen method :

The formula for calculating expected lighting levels by this method is

$$E = \frac{n \times N \times F \times LLF \times CU}{A}$$

E = Illumination in lux
n = No. of lamps per luminaire
N = No. of luminaries
F = Initial rated lamp lumens
LLF = Light loss factor for maintenance factor
CU = Coefficient of utilization
A = Area to be illuminated in sq. meters

Illumination Level E :

This is based upon the IES recommendation for illumination levels: Refer chart.

Initial lamp lumen F :

This is the initial rated lamp lumens of the selected lamp and is furnished by the lamp manufacturer

Coefficient of Utilisation CU :

This is the ratio of lumens reaching the working plane to the total lumen output of the lamp. The CU takes into account interreflectance of light in the room, the efficiency and light distribution of the luminaire, its mounting height and the geometry of the interior.

Light Loss Factor LLF :

Light Loss factors are those factors which contribute over a period of time to a decline in the light output of a given lamp – luminaire combination. This factor is usually considered to be the Lamp Lumen Depreciation (LLD) times the Luminaire Dirt Depreciation (LLD).

Point by Point Calculation :

The point by point method enables the calculation of illumination at a particular point at any orientation on a surface. The calculations are based upon the principles of the inverse square law and cosine law.

$$E \text{ (lux)} = \frac{I \times \cos^3 \alpha}{h^2}$$

$$E \times \frac{I}{h^2}$$

LUMINAIRES

Currently recommended illuminance values as per IES

Area of Activity	Illuminance on Task In Lux 1
Aircraft Industry	
Maintenance area	750
Inspection area	1000
Paint Shop	1000
Testing area	750
Instruments assembly	1500
Electrical assembly	1500
Explosives Manufacturing	
Furnaces, Boiling Tanks, Driers	200
Mechanical furnaces, mechanical driers, generators	500
Paint Shop	
Simple spraying	200
Fine finishing	500
Extra fine finishing	2000
Paint Manufacturing	
Processing	200 – 500
Mix comparison	10000 – 2000
Electricity generating station	
Boilers area	50
Cooling towers	50
Fuel handling	50
Storage tanks	10
Transformer yards	50
Turbine areas	50
Petroleum, Chemical and Petrochemical Industry	
Process areas	
General process units	
Pump rows, valves, manifolds	50
Heat exchangers	30
Maintenance platforms	10
Operating platforms	50
Cooling towers (equipment areas)	50
Furnaces	30
Ladders and stairs (inactive)	10
Ladders and stairs (active)	50
Gauge glassed	50
Instruments (on process units)	50
Compressor house	200
Separators	50
General area	10
Control rooms and houses	
Ordinary control house	300
Instrument panel	300
Console	300
Back of panel	100
Central control house	500
Instrument panel	500
Console	500
Back of panel	100
Speciality process units	
Electrolytic cell room	50
Electric furnace	50
Conveyors	20
Conveyor transfer points	50
Kilns (operating area)	50
Extruders and mixers	200
Nonprocess areas	
Loading, unloading, and cooling water pump houses	
Pump area	50
General control area	150
Control panel	200
Boiler and air compressor plants	
Indoor equipments	200
Outdoor equipments	50
Tank fields (where lighting is required)	
Ladders and stairs	5
Gauging area	10
Manifold area	5
Loading racks	
General area	50
Tank car	100
Tank trucks, loading point	100
Electrical substations and switch yards	
Outdoor switch yards	20
General substation outdoor	20
Substation operating aisles	150
General substation indoor	50
Switch racks	50
Plant road lighting (where lighting is Required)	
Frequent use (trucking)	4
Infrequent use	2
Plant parking lots	1
Aircraft obstruction lighting2	
Buildings	
Laboratories	
Qualitative, quantitative and physical test	500
Research, experimental	500
Pilot plant, process and speciality	300
ASTM equipment knock test	300
Glassware, washrooms	300
Fume hoods	300
Stock rooms	150
Warehouse and stock rooms	
Indoor bulk storage	50
Outdoor bulk storage	5
Large bin storage	50
Small bin storage	100
Small parts storage	200
Counter tops	300
Repair shop	
Large fabrication	200
Bench and machine work	500
Craneway, aisles	150
Small machine	300
Sheet metal	200
Electrical	200
Instrument	300

Area of Activity	Illuminance on Task In Lux 1
Change house	
Locker room, shower	100
Lavatory	100
Clock house and entrance gatehouse	
Card rack and clock area	100
Entrance gate, inspection	150
General	50
Cafeteria	
Eating	300
Serving area	300
Food preparation	300
General, halls, etc.	100
Garage and firehouse	
Storage and minor repairs	100
First aid room	700

Iron and Steel Industry

Area of Activity	Illuminance on Task In Lux 1
Open hearth	
Stock yard	100
Charging floor	
Pouring side	
Slag pits	200
Control platforms	300
Mold yard	50
Hot top	300
Hot top storage	100
Checker cellar	100
Buggy and door repair	300
Stripping yard	200
Scrap stockyard	100
Mixer building	300
Calcining building	100
Skull cracker	100
Rolling mills	
Blooming, slabbing, hot strip	
Hot sheet	300
Cold strip, plate	300
Pipe, rod, tube, wire drawing	500
Merchant and sheared plate	300
Tin plate mills	
Tinning and galvanizing	500
Cold strip rolling	500
Motor room, machine room	
Inspection	
Black plate, bloom and billet chipping	1000
Tin plate and other bright surfaces	2000

1 These illumination values are not intended to be mandatory by enactment into law. They are a recommended practice to be considered in the design of new facilities. All illumination valves are averages maintained levels.

2 Refer to local FAA regulations for required navigational and obstruction lighting and marking.